

***“What are the impacts, implications and /or collateral effect of NFDRS proposed changes to itself and other potential applications outside wildfire pre-planning, suppression response arena?”***

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# Presentation arrangement

- Review my background
- Present a recommended course for consideration
- Share an ***“opening remark”***
- Present a ***“real operational example”*** of NFDRS
  - examining its working outputs as well as what is missing.
  - The goal is to share ***“the possibilities of NFDRS used at the local level which is within the bounds of its application as well as beyond its traditional application.*”**
- Summation
  - Address the impact of the proposed changes on ***“NFDRS’s main philosophical principles”*** and local user community. The principles are the foundation on which the system was built. With current information and implementation of the proposed changes, principles would also require change.

# Opening Remarks

- The points to be raised are technical in nature and it would be helpful if everyone had a comprehensive knowledge of:
  - NFDRS publications GTR INT-39, GTR PSW-82, GTR PSW-84, GTR INT-169 & RP SE-273, RP NC-274, FMN Vol.49 No.4 (1988), FMT Vol.79 No3.(2011)
  - Field experiences with operating NFDRS, and
  - Original intent and oversight of the ***“NFDRS Technical Review Committee”***.
  - This committee was sensitive to user needs in 1978 which are just as relevant today.
- Therefore, this presentation will be kept brief and the goal to be understandable and open a dialogue.

# Recommended course for action

- ***Assemble a knowledgeable task group*** of Fire Danger, Smoke, Fuels, Emission, Research, Wildfire, Prescribed fire, Fuels, and Archaeologist personnel from the various sections of the country to vet the possibilities & future of NFDRS.
- Of most importance is the ***inclusion of local initial attack fire suppression and prescribed fire crew personnel.***
  - “mission”
    - a) Determine the future of NFDRS.
    - b) Is it for wildland fire which includes wildfires and prescribed fires or is it only for wildland wildfires
    - c) What products and training are needed for each customer at state, federal, strategic partners and/or public entities and their various levels of responsibility. Different products are needed for different users who have different responsibilities.

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# Before presenting a “real operational example,” what are the current NFDRS outputs?

- NFDRS was originally designed “50 years ago” to support effective wildfire: preparation planning, suppression response and prevention.
- NFDRS outputs have decreased over time with the remaining ones designed to give a “realistic appraisal” of the potential upper limits of a wildfire’s behavior through:
  - the Spread and Energy Release Components coupled with the Burning Index while,
  - Ignition Component provided an expectation of fire occurrence requiring suppression action and spotting.

# Current NFDRS Outputs / Behavior Outputs

- Spread Component
- Energy Release Component
- Burning Index
  - $BI/10$  = Flame Length in ft.
- Ignition Component
- ~~Man-Caused Occurrence Risk Index~~
- ~~Lightning Caused Occurrence Index~~
- ~~Fire Load Index~~
- Keetch Byrum Drought Index
- 1, 10, 100 & 1000 hrs FM
- Live Herb. & Woody FM

- Surface Rate of Spread
- Heat per Unit Area
- Fireline Intensity
- Flame Length
- Probability of Ignition
  
- Inputs to BEHAVE
- Inputs to BEHAVE

# Real Operational Example – *Setting The Stage*

- 1) NFDRS was ***designed for wildfire operations*** to support those agencies and their personnel tasked with making decisions about how best to manage for potential wildfires and initial suppression response with limited fire suppression resources during the fire season.
- 2) However, NFDRS is a tool that can have a ***broader application*** than its original design. NFDRS information can be used for ***prescribed fire , smoke management, fuels management, & emission data programs.***
- 1) The ***possibilities are unlimited by having vision & utilizing the advancing science and the willingness to be adaptive.*** The following real example was born out of escaped prescribed fires and the need to increase opportunities to burn under a restrictive environment of NC's smoke management program.

# **Prescribed Fires – were escaping & State Forestry fire suppression resources were being requested to assist in suppression efforts**

**2 USFWS**

**1 Private Contractor**

**1 USFS**

**1 Nature Conservancy**

**1 NC State Parks**

**2 NCDFR**



**One Common Denominator of these escapes:**

**“no one was checking NFDRS numbers!”**

# Operational Research Evaluation Burns

- OREBS is a process in NC to increase burning opportunities.
- Through use of Atmospheric Dispersion Models HYSPLIT or VSMOKE prescribed fire was not restricted to acres and / or emission limitation but on evaluating and keeping downwind PM2.5 emissions impacts on smoke sensitive area minimal but acceptable
- **Some of the Decision Support Tools used: *NFDRS, ESP, FEPS, ADM-VSMOKE, Rawinosondes***

# **The “current NFDRS” has application to prescribed fire, fuels, smoke & emissions management**



**On April 6 100 acres of Pocosin fuels were prescribe burned on a large fire growth day for wildfires as assessed by NFDRS and wind profile analysis.**

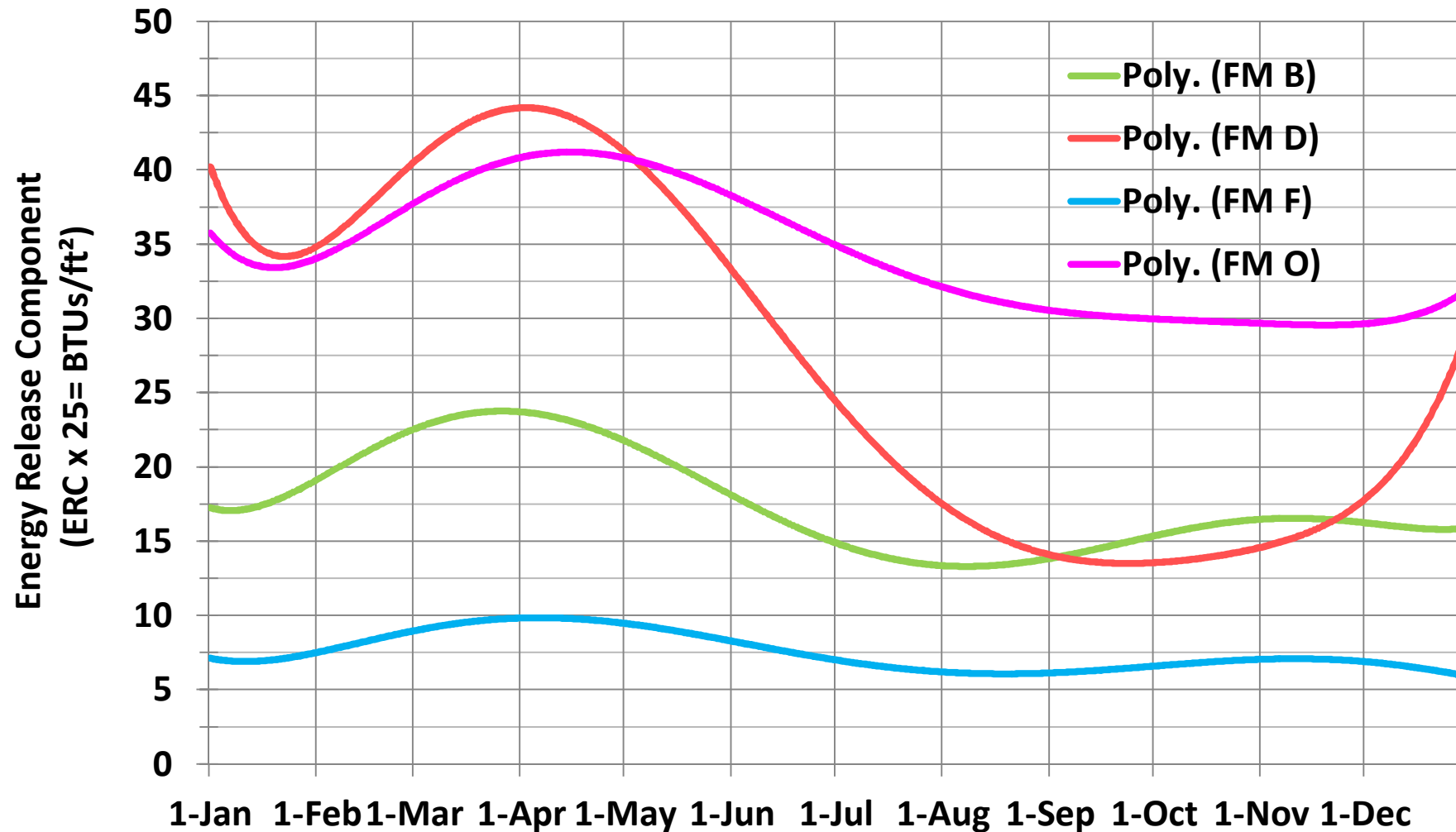
# Readings for the Camp Lejeune Burn

DOD Camp Lejeune NFDR Station – Sandy Run

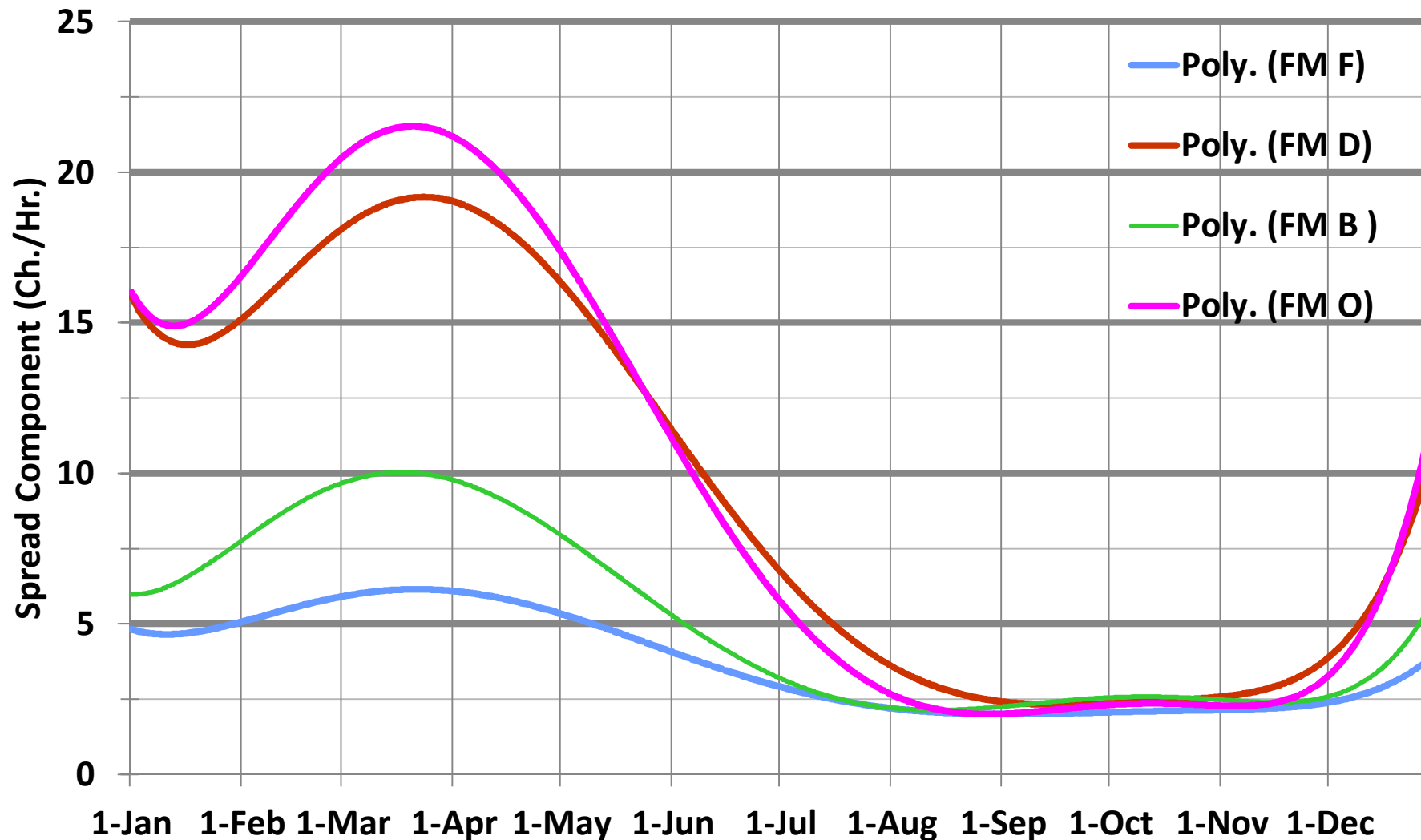


Station ID	Obs Dt	Tm	O T	MSGC	WS	WDY	HRB	1H	10	HU	TH	XH	IC	SC	EC	BI	SL	R	KBDI
319505	040710	13	F	701P3	11	70	7	7	11	15	18	18	29	43	44	97	4	H	171
319505	040710	13	F	7G1P3	11	70	7	7	11	15	18	18	28	12	30	46	3	M	171
319505	040610	13	O	701P3	7	70	6	7	8	15	19	19	24	28	47	82	4	H	154
319505	040610	13	O	7G1P3	7	70	6	7	8	15	19	19	23	8	31	37	3	M	154

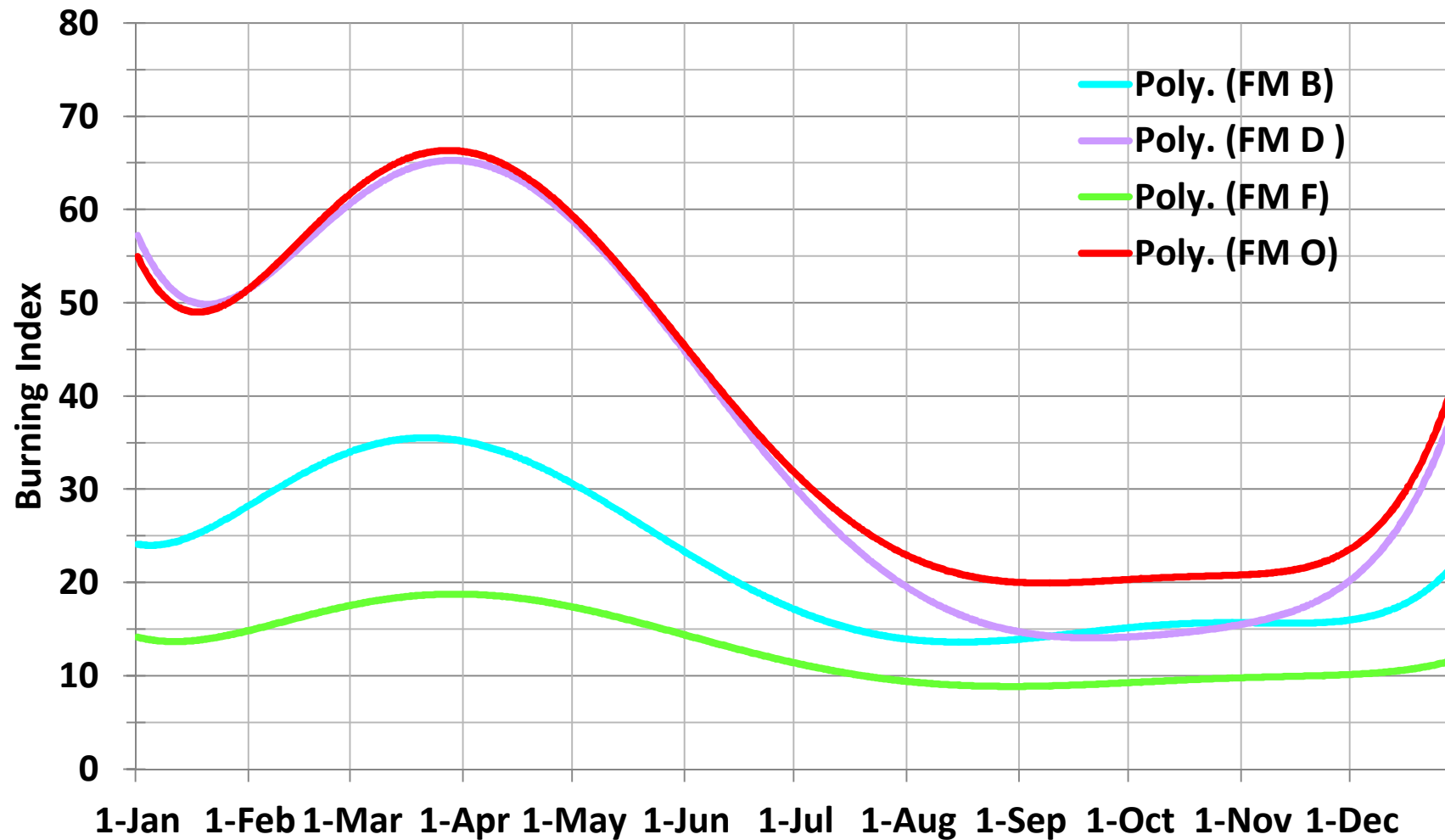
# Comparing ERC Trendlines amongst NFDRS Brush Fuel Models



# Comparing SC Trendlines amongst NFDRS Brush Fuel Models



# Comparing BI Trendlines amongst NFDRS Brush Fuel Models



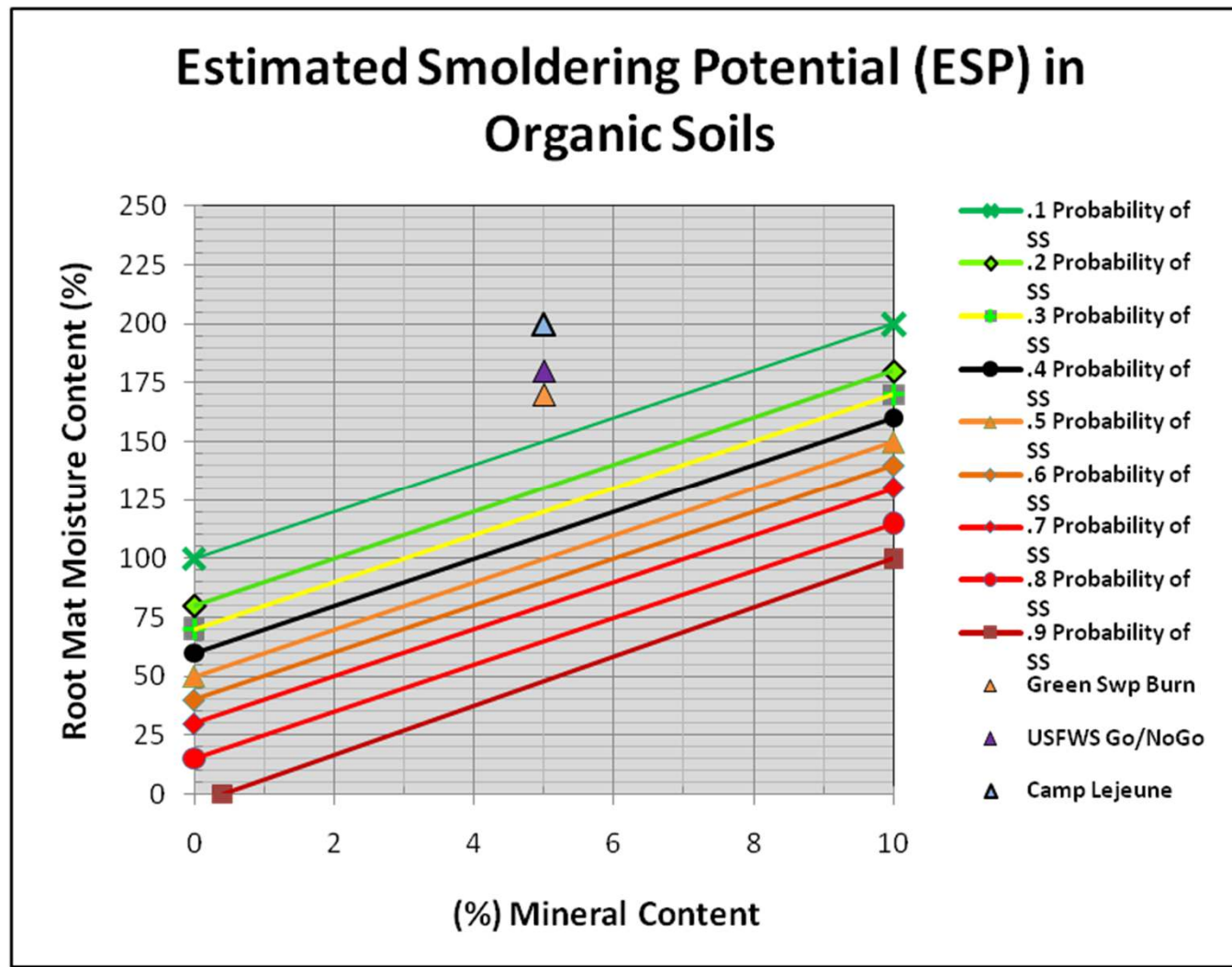
# Organic Soils, ground fuels, is an additional fuel class recommended by John Deeming to be inclusive to NFDRS enhancement



Post burn evaluation reveals “zero”  
ground ignitions in the organic soil



# On the Camp Lejeune Burn – Estimated Smoldering Potential was used to assess the fire danger for organic soils



**ESP probability of sustaining ground fire ignition is < 10%. This facilitates the decision to exclude organic soil from emission estimates and lessens mop-up concerns.**

**Just as NFDRS was not used to assess burning conditions of surface fuels for prescribe fires in Slide 8;**

**ESP was not used to assess burning conditions of organic soils when surface fuels were prescribe burned.**



# NFDRS fuel moisture inputs are key

Event Information

Fuel Loading

Fuel Moisture

Consumption

Hourly Input Data

Fuel Profile

Fuel Loading Profiles (tons per acre)

Name	Natural Fuels					Slash Fuels		NFDR Model	FCCS Fuelbed	Reference	Clear
	Canopy	Shrub	Grass	Woody	Litter	Bdcst	Pile				
1 Med Forest	1.02	4.11	0.10	0.00	4.17	0.00	0.00	223.20	...	170	...
2 Unused	0.00	0.00	0.00	0.00	0.00	0.00	0.00	...	...	...	...
3 Unused	0.00	0.00	0.00	0.00	0.00	0.00	0.00	...	...	...	...
4 Unused	0.00	0.00	0.00	0.00	0.00	0.00	0.00	...	...	...	...
5 Unused	0.00	0.00	0.00	0.00	0.00	0.00	0.00	...	...	...	...

To view suggested values for different levels of loading (none, light, medium, and heavy), double click on the profile and column of interest (or select a profile and column and press F7). A worksheet with suggested loading values will appear. You can select a loading value from the worksheet to populate the profile and column selected above.

Values from an NFDR fuel model/ FCCS Fuelbed are displayed in blue. Values entered by the user or chosen from the worksheet are displayed in red. Choose an NFDR fuel model/ FCCS Fuelbed to reset these values.

Save Cancel

Event Information

Fuel Loading

Fuel Moisture

Consumption

Hourly Input Data

Fuel Moisture Profiles (Percent Moisture)

Fuel Moisture Profile	1-hr	10-hr	100-hr	1000-hr	Live	Duff
Very Dry	4	6	8	8	60	25
Dry	7	8	9	12	80	40
Moderate	7	8	15	19	90	200
Moist	10	12	12	22	130	150
Wet	18	20	22	31	180	250
Very Wet	28	30	32	75	300	400

Values displayed in blue represent either FEPS default fuel moisture values (upper table) or FEPS calculated percentage consumed (lower table). Values overwritten by user are displayed in red. Changes in fuel moisture profiles (upper table) will not affect percent consumed (lower table) until saved.

Percent of Fuel Loading Consumed

Fuel Profile	Fuel Moisture Profile	Canopy	Shrub	Grass	Woody	Litter	Bdcst	Piles	Duff
Med Forest	Very Dry	86	89	94	60	100	100	99	86
Unused	Very Dry	86	89	94	60	100	100	99	86
Unused	Very Dry	86	89	94	60	100	100	99	86
Unused	Very Dry	86	89	94	60	100	100	99	86
Unused	Very Dry	86	89	94	60	100	100	99	86

Cancel Save

Event Information

Fuel Loading

Fuel Moisture

Consumption

Hourly Input Data

Fuel Consumption (tons per acre)

Flaming

Short Term Smoldering < 2 hrs

Long Term Smoldering

Hover over the column headings for an explanation of abbreviations.

Reset

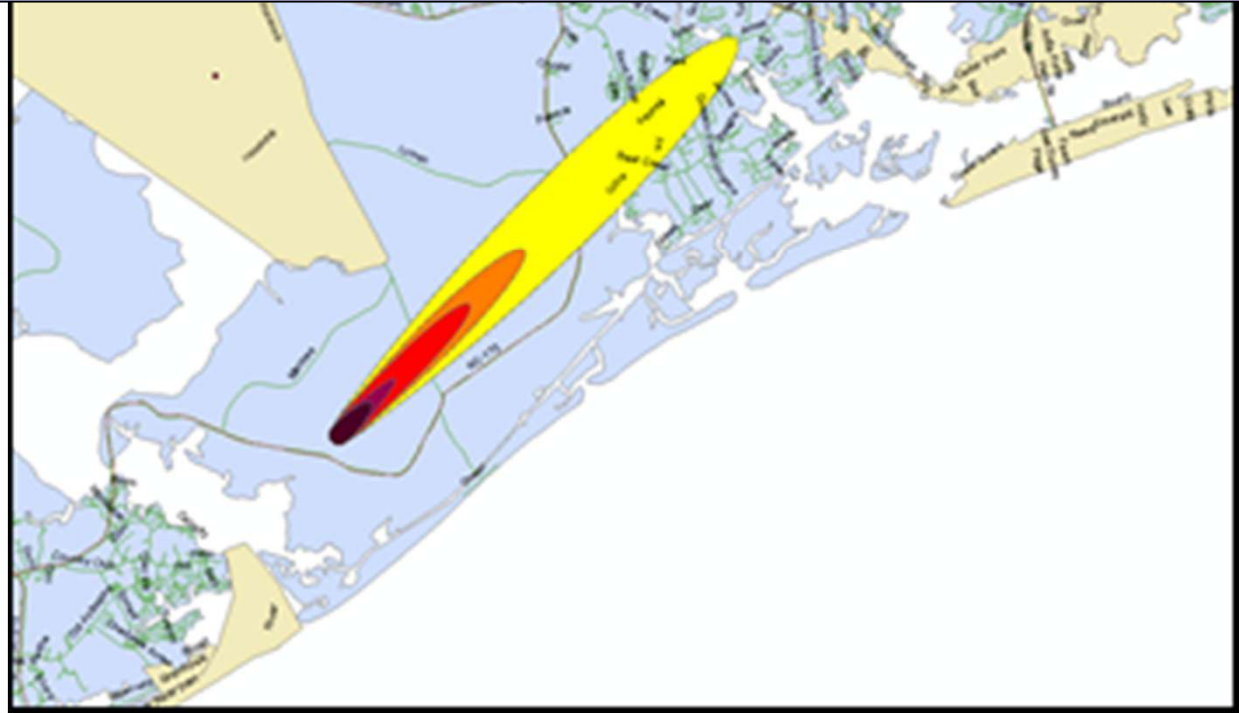
Calculate and Save

Cancel

# NFDRS moistures are necessary for determining Emissions and Emission Input File for ADM's

With NFDRS moistures FEPS consumption file is completed & ingested into Atmospheric Dispersion Model VSMOKE run. It displays the PM2.5 impacts to downwind smoke sensitive areas. This can support or not Go / No-Go Decisions.

NFDRS moisture contents therefore assist in projecting consumption, PM 2.5 concentrations contours & visibility impacts downwind (100 & 1000 hr.).



Distance from fire	PM2.5 (ug/m3)	CO (ppm)	Distance from fire	PM2.5 (ug/m3)	CO (ppm)
328 ft	3,623.89	38.95	2.47 mi	225.76	4.12
413 ft	3,145.57	34.05	3.11 mi	173.02	3.57
518 ft	2,714.53	29.63	3.92 mi	129.76	3.13
656 ft	2,329.98	25.68	4.94 mi	96.84	2.79
823 ft	1,990.41	22.20	6.21 mi	72.85	2.54
1037 ft	1,693.45	19.16	7.82 mi	55.90	2.32
0.25 mi	1,436.03	16.52	9.85 mi	44.19	2.25
0.31 mi	1,214.60	14.25	12.40 mi	36.20	2.17
0.39 mi	1,025.38	12.31	15.61 mi	30.82	2.11
0.49 mi	864.37	10.66	19.65 mi	27.27	2.07
0.62 mi	726.54	9.24	24.74 mi	25.24	2.06
0.78 mi	605.05	8.00	31.14 mi	24.06	2.04
0.98 mi	497.13	6.89	39.21 mi	23.28	2.03
1.24 mi	427.23	6.18	49.36 mi	22.69	2.03
1.56 mi	357.20	5.46	62.14 mi	22.21	2.02
1.96 mi	289.23	4.76			

AQI Category	2013 Revised Breakpoints
Good	0 – 12.0
Moderate	12.1 – 35.4
Unhealthy for Sensitive Grps.	35.5 – 55.4
Unhealthy	55.5 – 150.4
Very Healthy	150.5 – 250.4
	250.5 – 350.4
Hazardous	350.5 - 500

# Estimating Fuel Consumption & Emissions Utilizing Burning Index

## Estimating Fuel Consumption for the Upper Coastal Plain of South Carolina

Scott L. Goodrick, Dan Shea, and John Blake

ABSTRACT

Recent changes in air quality regulations present a potential obstacle to continued use of prescribed fire as a land management tool. Lowering of the acceptable daily concentration of particulate matter from 65 to 35  $\mu\text{g}/\text{m}^3$  will bring much closer scrutiny of prescribed burning practices from the air quality community. To work within this narrow window, land managers need simple tools to allow them to estimate their potential emissions and examine trade-offs between continued use of prescribed fire and other means of fuels management. A critical part of the emissions estimation process is determining the amount of fuel consumed during the burn. This study combines results from a number of studies along the Upper Coastal Plain of South Carolina to arrive at a simple means of estimating total fuel consumption on prescribed fires. The result is a simple linear relationship that determines the total fuel consumed as a function of the product of the preburn fuel load and the burning index of the National Fire Danger Rating System.

**Keywords:** prescribed fire, emission, fuel consumption

Estimates of fuel consumption per unit area (FC) and emissions of particulate matter  $<2.5 \mu\text{m}$  in diameter ( $\text{PM}_{2.5}$ ) are required to strategically manage the smoke from prescribed fire programs in the South and to assess their impacts on air quality. New federal regulations (US Environmental Protection Agency 2007) have lowered the 24-hour maximum  $\text{PM}_{2.5}$  exposure for the public from 65 to 35  $\mu\text{g}/\text{m}^3$ . Although the annual limit has not changed (15  $\mu\text{g}/\text{m}^3$ ), the cumulative impact of all sources of  $\text{PM}_{2.5}$  emission may also push designated urban environments over the annual threshold and into nonattainment status. Failure to achieve air quality standards could severely restrict prescribed fire programs designed to reduce hazardous fuels, to restore red-cockaded woodpecker (RCW) habitat (*Picoides borealis*) and native pine savanna communities, and to maintain wildlife habitat for game species. The current recovery plan for the RCW (US Fish and Wildlife Service 2003) places emphasis on frequent prescribed fire in restoring and sustaining RCW habitat, and frequent prescribed fire is critical to restoration and conservation of grass-forb savanna communities (Glitzenstein et al. 2003).

The Augusta-Aiken area, between Georgia and South Carolina, is an urban zone potentially affected by prescribed burning at the Savannah River site (SRS) and other forestlands in South Carolina and Georgia. Recent assessments by the South Carolina Department of Health and Environmental Control (Lawson 2008) and the Georgia Environmental Protection Division (Johnston 2008) indicate that Augusta-Aiken area annual  $\text{PM}_{2.5}$  levels are close to the 15  $\mu\text{g}/\text{m}^3$  annual standard. Similar to many other federal agencies in the South, the Department of Energy has a goal to recover the RCW, restore pine savanna communities, manage wildlife habitat for game species, and manage hazardous fuels (US Department of Energy 2005). To achieve these goals, the objective for the annual prescribed fire program is 22,500 ac, a significant increase from the

historical average of 13,000 ac (Kilgus and Blake 2005). Therefore, assessing the impacts of the fire programs on air quality and identifying strategies to mitigate those impacts are critical. Current regional smoke management guidelines (US Forest Service 1989) and smoke management regulations within South Carolina (South Carolina Forestry Commission 2005) are designed to limit undesirable smoke impacts. However, they do not provide data to estimate FC and the resulting  $\text{PM}_{2.5}$  emissions.

The basic method to estimate  $\text{PM}_{2.5}$  emissions from prescribed fires involves three independent variables: FC, area burned, and the contaminant emission factor. If these variables are measured or can be calculated, then the following equation is used:  $\text{PM}_{2.5} \text{ (mass)} = \text{FC (mass per unit area)} \times \text{Area} \times \text{PM}_{2.5} \text{ emission factor (mass/mass)}$ .

$\text{PM}_{2.5}$  emission factors for wildland and prescribed fire are summarized by Battey and Battey (2002). Urbanski et al. (2008) recently published emission factors for a large number of southern prescribed fires, including fire fires at the SRS. Emission factors vary by combustion stage and fuel type, but the bulk values for individual burns are far less variable than FC. The FC term integrates the fuel bed structure and total available fuel loading (TF), which is the greatest source of uncertainty in determining FC, as well as environmental conditions affecting fire behavior, and is therefore the greatest source of variation in the emission equation (Peterson 1987, Sandberg et al. 2002). Empirical estimates of FC from prescribed fires in the South are available from a limited number of studies. Flough (1968, 1978) produced a large number of FC observations and generated relationships predicting FC, as a function of TF and bulk duff-litter moisture content (MC) in northern Florida and southern Georgia. Ferguson et al. (2002) related litter and duff consumption to diurnal changes in weather and moisture variables at Eglin Air Force Base in the Florida panhandle, and Snyder et al.

**Southern High Resolution Model Consortium highlights another potential promising application of NFDRS whereby the Burning Index can be used to ascertain emissions.**

Manuscript received September 17, 2008; accepted June 18, 2009.

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# Summary

- Several of the ***NFDRS principles will be impacted and will require rewriting thus NFDRS Philosophy has changed and customer base is being selectively shaped. Specific impacts are to the:***
  - Concept of containment as it pertains to behavior potential of the head fire
  - Fire Behavior Outputs being physically & meaningfully interpretable, and
  - Meaning of low spatial resolution to the area to be fire danger rated



## In closing

- I will look forward to reviewing the Fire Danger Subcommittee ***technical document*** concerning the proposed changes.
- I hope I have highlighted enough to show the ***potential*** that NFDRS has ***beyond a narrowly defined fire danger scope***.
- NFDRS can be a valued commodity in its present delivery provided ***training is developed for each customer base***.
- NFDRS Technical Review Committee wanted NFDRS Outputs to be meaningful with regards to fire behavior ***“addressing local concerns”***. This was valid in 1978 & is still valid in 2015.